Providing Complete Precision Timing Solution for Hospitals by GPS Time Synchronized with MCS

Younis H. Karim Aljewari, R. Badlishah Ahmad and Ali Ameer Ahmed

***Abstract*— The time is very important in the life and has a special significance for hospitals, Where is specially used in operating rooms, Nurse Call System (NCS) , various medical tests and many other medical services. Those important things are mainly to use Master Clock System (MCS) in the hospitals. In this paper we provided high precision time for hospitals by used Global Positioning System (GPS) time synchronized with MCS. The time will get synchronized from satellite via GPS according to the Time Zone. GPS receivers can provide precise time, speed, and course measurements. Westerstrand GPS unit uses a miniature 12-channel GPS will use in the system and its compact size and low power consumption make it ideal for this application. The system consists of Master clock control unit, GPS receiver with antenna and related accessories.**

Keywords- GPS, MCS, SYNCHRONIZE, NTP, UDP

I. INTRODUCTION

The Global Positioning System is a satellite based navigation system operated and maintained by the U.S. Department of Defense (DOD). GPS is the most accurate technology available for easy timing. By computing the distance to satellites orbiting the earth, a GPS receiver can calculate an accurate position. This process is called satellite ranging. The GPS broadcast a form of Coordinate Universal Time (UTC). GPS contain a constellation of 24 satellites providing worldwide, arrange in 6 orbital planes with 4 satellites per plane. GPS can provide service to an unlimited number of users since the user receivers operate passively (i.e., receive only). The system utilizes the concept of one-way. Time of arrival (TOA) ranging. Satellite transmissions are referenced to highly accurate atomic frequency standards onboard the satellites. The receiver clock will generally have a bias error from system time. Further, satellite frequency generation and timing is based on a highly accurate free running cesium or rubidium atomic clock, which is typically offset from system time. Although originally conceived for military needs, GPS has a broad array of civilian applications including surveying, marine, land, aviation, and includes altitude, requires four satellite ranges. Westerstrand GPS receiver with antenna 122980-00 we used in the system and its compact size and low power consumption make it ideal for this application it is depicted in figure (1).

Master Clock System (MCS) having Microprocessor-based, software-controlled unit complying with Class A device requirements in 47 CFR 15, Network Time Protocol (NTP) time server for TCP/IP based networks, Embedded LINUX operating system on a faster 133 MHZ processor is depicted in figure (2), IP based with GPS receiver and accuracy of the order of microsecond using GPS transmissions.

Figure 1: GPS receiver with antenna122980-00

This module can connect with different types of slave clocks, relay outputs, GPS and different types of communication interfaces etc. The time central can be configured via the Ethernet module which also can be used for supervision and alarm handling. Power supplies are available in different voltage and current versions. Dual power supplies can be used for higher stability and redundancy.

Figure 2: Controller of MCS

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II. DESCRIPTION OF SYSTEM

The system consist of Master clock control unit, GPS receiver with antenna and related accessories, Secondary indicating clocks with RJ45 Ethernet jack for connecting to the system to TCP/IP network and System software for control and management.

MCS contained digital master clock, secondary clocks. Ethernet clock synchronization for maintain correct synchronized time correction signals from the master clock to all the secondary clocks. The Ethernet interface can be configured to operate in two modes, NTP or Universal Datagram Protocol (UDP). Using NTP mode, the clocks will obtain the time directly from the time servers available in the internet or local network. The UDP mode, allows the clocks to receive time broadcast form a local master clock. The digital secondary clocks are seamlessly integrated with the TCP/IP network through Structural Cabling Network (SCN). An RJ45 jack is available at the back of the clock for connecting to the SCN. If the GPS signal is lost for any reason, the Master Clocks will continue to function in flywheel mode due to the (TCXO) in its chassis. Upon re-acquisition of the GPS signal, the master clock automatically re synchronizes.

In figure (3), we can see system block diagram to description of system. The power – over – Ethernet (PoE) standard based on IEEE 802.3af used for providing power to the secondary clocks connected to the LAN. The switches in the distributor panel to the secondary clocks are connected with PoE compatible switch. In addition to updating slave clocks, the master clock can send the time to all computers on Local Area Network (LAN).

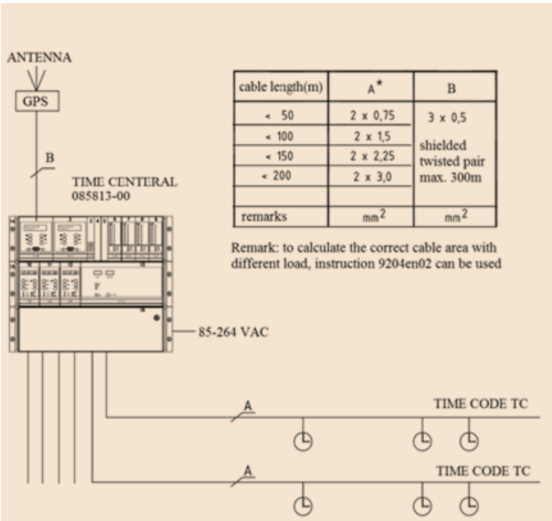

Figure 3: System Block Diagram

A priority list is stored in the modules that tell them which module they shall synchronize the time to. If the module with the highest priority is unavailable the next module in the list is used as the time reference. If all modules in the time central are unavailable, the modules will continue to run on their own built in time base. When a module with priority is available again, the time is synchronized to that module. This is done automatically and no manual programming is needed.

The highest priority is normally given to a synchronization module with a GPS- receiver/antenna connected. If the time central is equipped with an Ethernet module acting as a NTP-client this should be set to top priority. The time central with Ethernet module can act as NTP time server and/or client.

Each module has LED's on the front indicating status, alarm and primary timeserver. Each module also has LED's to indicate module specific tasks. A sum alarm is available in the back of the time central via a potential free switchover contact.The cable area is calculated with maximum load (1000mA) and worst case situation, all clocks connected at the end of cable. The maximum allowed voltage drop from the master clock to slave clock is 2.5v.

The system will perform the following functions:

1). Maintain correct synchronized time and transmit time-correction signals over SCN from a master clock to all types of secondary indicating clocks.

2). Initiate and execute programs for scheduled automatic operation of remote devices.

3). Provide for manual control of programmed signal and equipment switching circuits.

4). Communicate with remote PC for access to Universal time coordinated (UTC) time base and to permit programming from remote location.

5). Regulate system timing functions using power-line frequency, backed up for power outages by an internal battery-powered, crystal-controlled oscillator, and automated periodic reference to NIST or UTC time signals via GPS receiver and antenna. Reference time signals shall be automatically accessed at programmable intervals.

III. INSTALLATION OF SYSTEM

The weatherproof GPS head-end Antenna / Receiver we used in conjunction with a GPS demodulator module so that antenna cable lengths of up to 100 meters of the communication cable is twisted-pair 1mm² which is utilized with the GPS head-end antenna / receiver separate from equipment plug strip and located in front of rack. The GPS antenna located at the roof to obtain best reception of signals and the accuracy of the order of microsecond using GPS transmissions is shown in figure (4).

Figure 4:GPS installation at the roof

GI flexible conduit was used to protect the communication cable in open area outside building on the roof and inside building we used PVC conduit, it was supported by clips on ceiling and walls.The installation of secondary clocks that operate according to electric signal from their Master Clock which is received accurate signal from GPS. Double-face ceiling mounted and wall mounted we installed in corridors and main entrance of hospital, see figure (5), Single-face, surface mount and wall mounted we installed in operation rooms and Doctors' offices; see figure (6). All clock locations are selected in order to view from maximum amount space. Final clocks location and mounting details we coordinated at site to the satisfaction of the hospital representative.

Figure 5: Clocks installed in corridor and main entrance

Figure 6:Clocks installed in operation rooms and Doctors' offices

Program instruction is programmed and reviewed through the 12 Key panel mounted keypad and displayed on the LCD display. It is possible to validate each instruction after programming. All program instruction is made by the keypad and user can changeable at any time.

The network cables are used to connect all slave units to The Master Clock Unit in order to transmit timing data and the loop-configuration network and not a star-configuration in order to use one communication line to all the slave units. The communication cable is twisted-pair 1mm² with a good shield therefore every node of the network must be ended with a T-connector having a socket in order to make easy connection to (or disconnection from) the slave unit.

IV. RESULTS & CONCLUSION

GPS is the most accurate technology available for easy timing, has been testing the system in comprehensive and sufficient to demonstrate compliance with each hospital specification requirement. Our time control strategy in the hospital is that the Master clock works in continuous time with high accuracy by using time data from GPS, whereas the Slave clocks works in discrete time. By the way, the observer always works and provides an estimation of the Slave state even if the Slave information is not sent continuously.

The system generates, saves and plots the user clock bias and drift for a specified number of receivers and time steps, by using a simplified second order model If the default data are used then the user clock bias and drift for the user are presented in Figure (7).

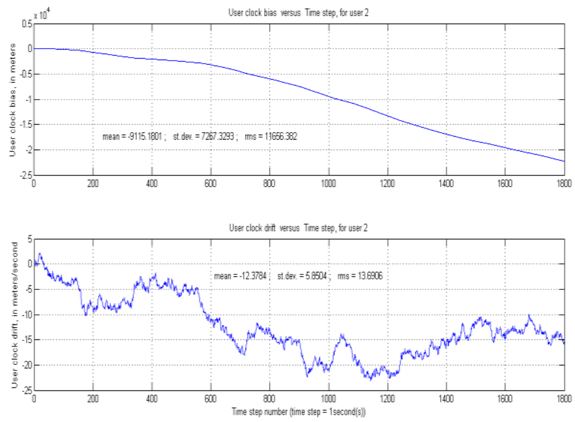

Figure 7: User clock bias and drift errors versus time step number

The GPS receiver is enable the Master Clock to synchronize with the Global Positioning system constellation of satellites, the accurate time is constantly fed to all slave and sub systems, we found timekeeping accuracy of the system without GPS is , + 3 to + 5 seconds per month, While time accuracy is + 500 nanoseconds from UTC during GPS signal availability. Less than two minutes the time to first fix from cold start. A 3-D position calculation, which Prime power: +8V to 35V (Power supply from Master Clock / Time Central) Power consumption: 0.3 watt (nominal).

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